PREVENTIVE CONSERVATION OF CULTURAL HERITAGE: AN INTEGRATED SYSTEM OF BIOLOGICAL AND MICROCLIMATE MONITORING

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Abstract

Cultural heritage preserved in indoor environments (museums, libraries, archives, etc.) is subject to *biodeterioration* caused by specific groups of biological agents called *biodeteriogens*. Several factors may affect the process of biodeterioration, depending on the chemical and physical characteristics of the materials, the state of conservation of the artefacts, the environmental conditions and the nutritional needs of biological agents.

The biological components of air (*bioaerosol*) can be a potential biodeteriogen for cultural property. In the case of artefacts made using organic materials, they can be identified in a specific fungal and bacterial microflora. Once deposited on the surface of cultural objects, these microorganisms can find favourable nutritional and environmental conditions, thus becoming biodeteriogens. Certain classes of airborne particles contain allergens or toxins, and can pose a risk to the health of operators and visitors. The prevention of biological risks is based on a thorough knowledge of aerobiological particles and the factors that affect their circulation, survival and growth in a specific environment, associated with a careful control of microclimatic parameters. Such an integrated system of biological (air and surfaces) and microclimatic monitoring, based on a methodological model, represents the basis for studying the "environment-artefact-man" complex in order to understand, assess and prevent biological risks. The proposed approach relies on the analysis of: 1) airborne microorganisms with active and passive methods; 2) the surface of cultural objects with non-

destructive and non-invasive techniques based on nitrocellulose membrane filters; 3) fungal spores with a spore trap (Hirst type) and microscope; 4) surface and airborne allergens with immunoenzymatic assays; 5) airborne particles, with a laser particle counter; 6) indoor microclimatic conditions: air temperature, relative humidity, air velocity and distribution, light, temperature of surfaces, related with the conservation of cultural property and the risk of contamination by biological agents, are also analysed. The effect of ventilation strategies on the microclimate can be evaluated using computational fluid-dynamics (CFD) tools. A multiphysics approach combined with CFD is used to assess air ventilation and microclimate. Transient simulations, based on experimental data and run on three-dimensional models of the studied environment, allow to define preservation and maintenance criteria. CFD plays an important role in the prediction of damage and risk, as it helps to evaluate the efficiency, adequacy and reliability of any Heating, Ventilation and Air Conditioning (HVAC) system and its maintenance criteria, thus providing critical indications for indoor air quality control and energy saving. Studying both the biological and microclimatic quality of cultural heritage environments is fundamental to define adequate conservation methods and standards, and to protect the health of operators and visitors. This methodology is also an useful tool for managing cultural heritage sites and for choosing the best environmental control strategy when retrofitting buildings, especially in all those cases where a historical building is modified to become a museum, library or archive.